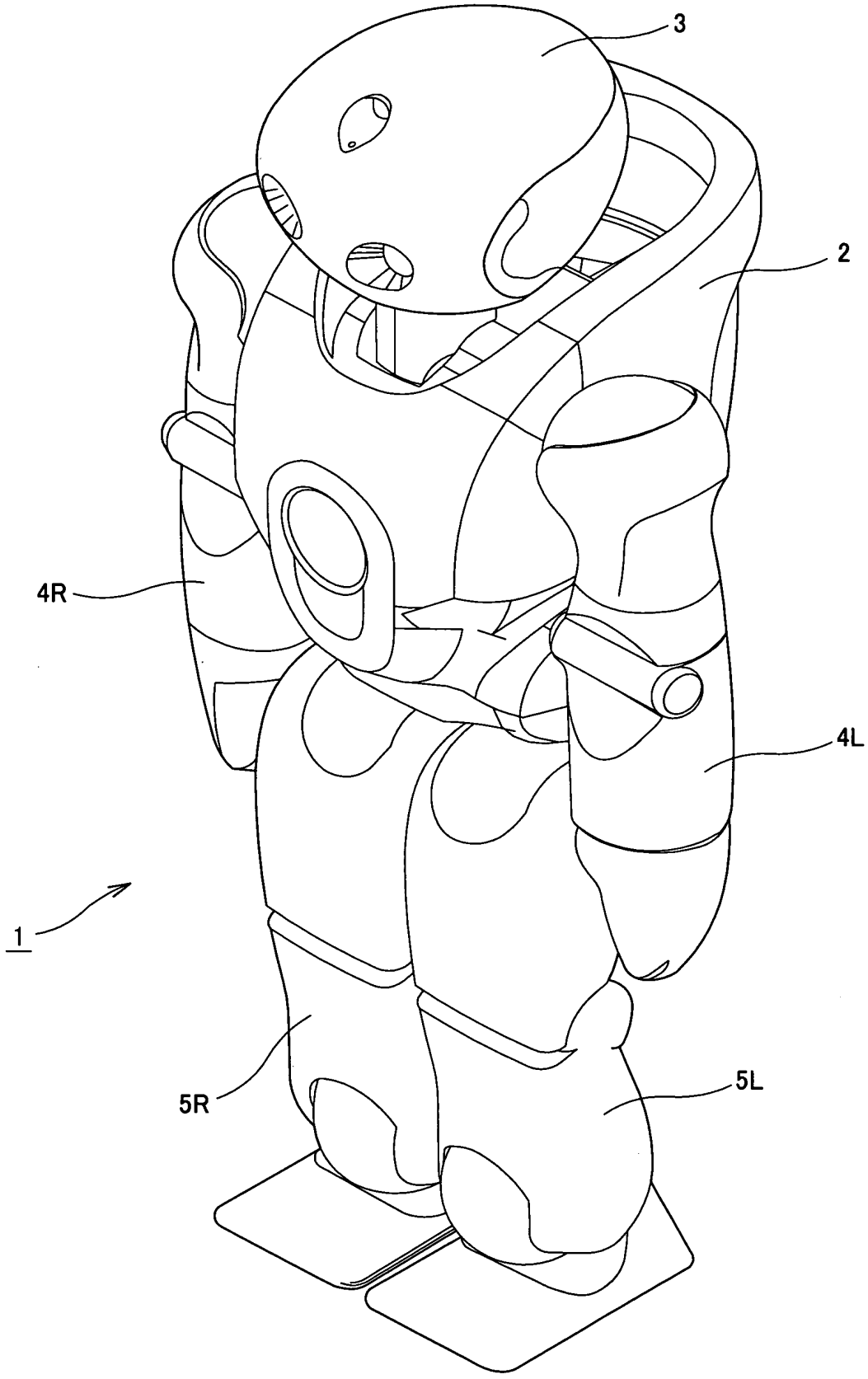


FIG. 1

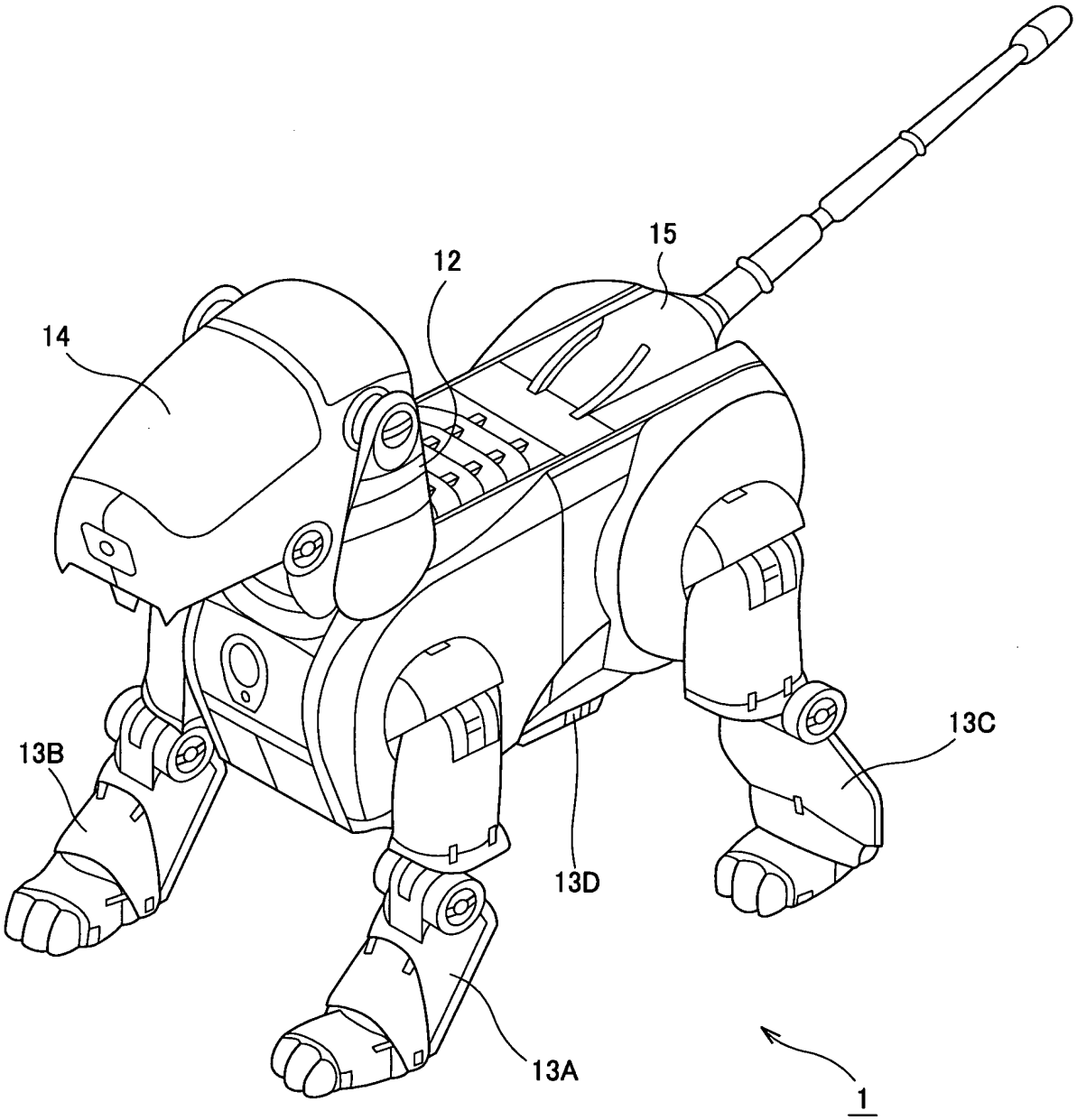


FIG.2

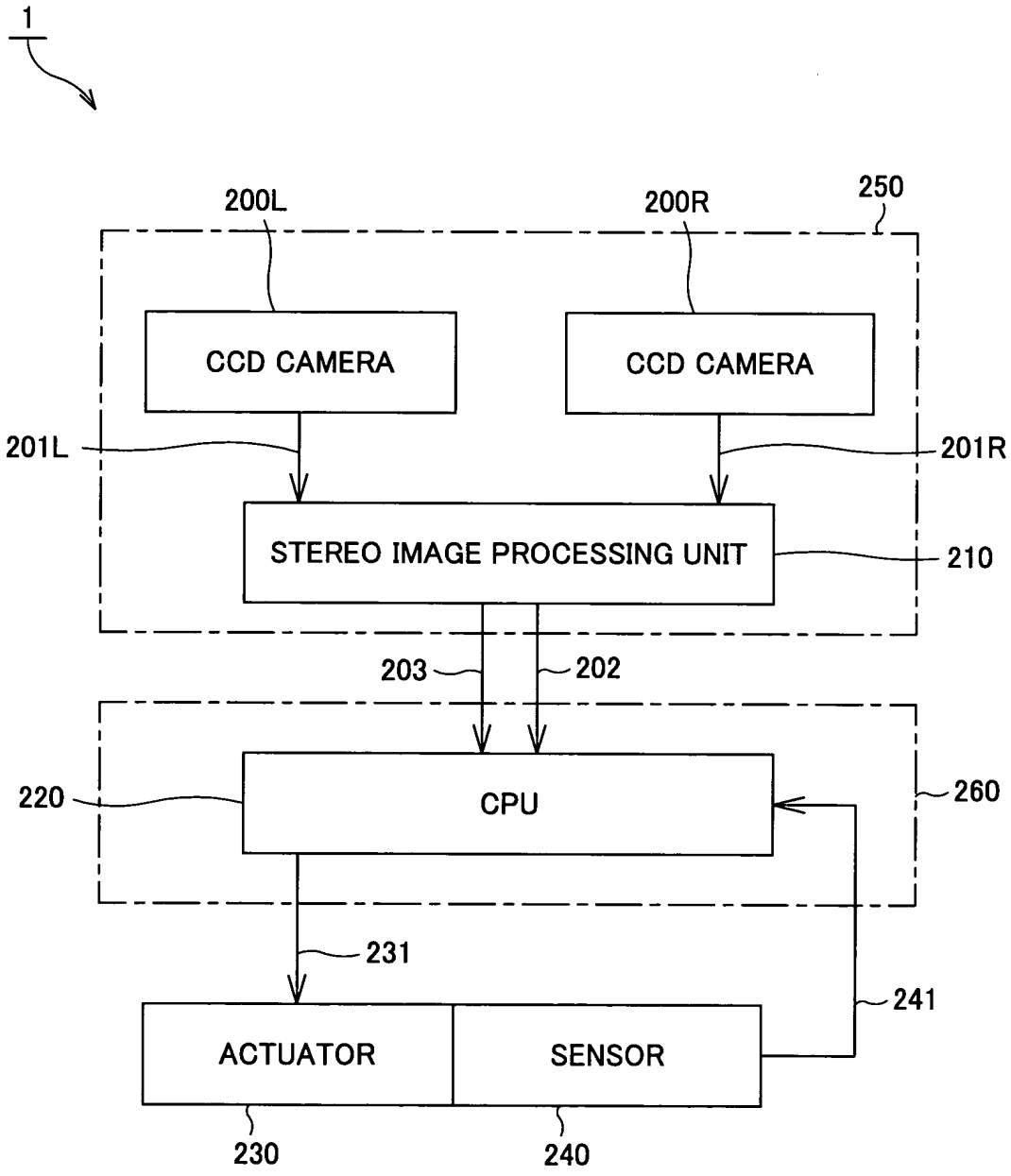

1
200L
200R
250
CCD CAMERA
CCD CAMERA
201L
201R
STEREO IMAGE PROCESSING UNIT
210
203
202
220
CPU
260
231
241
ACTUATOR
SENSOR
230
240

FIG.3

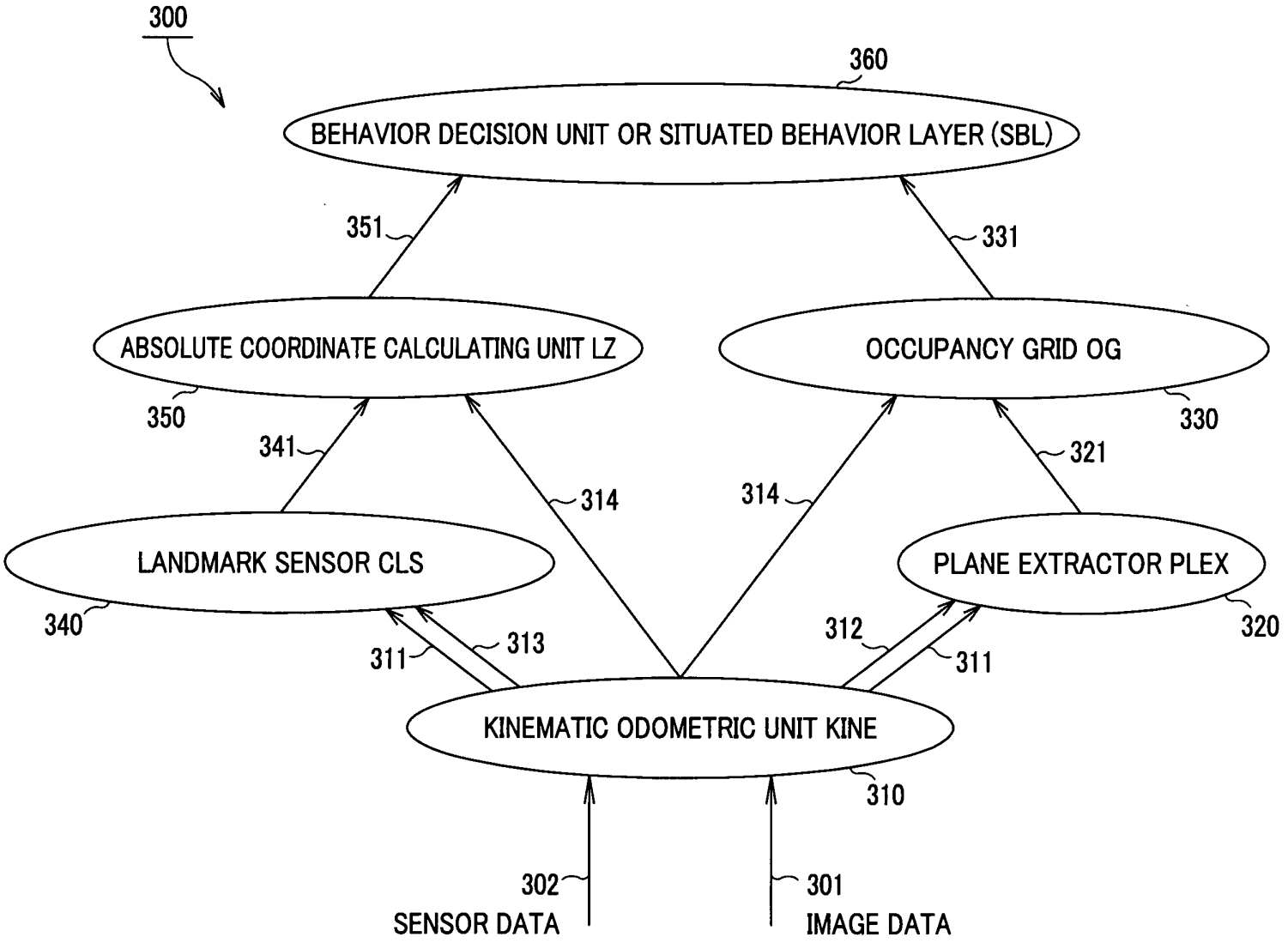

300
360
BEHAVIOR DECISION UNIT OR SITUATED BEHAVIOR LAYER (SBL)
351
331
ABSOLUTE COORDINATE CALCULATING UNIT LZ
OCCUPANCY GRID OG
350
330
341
321
314
314
LANDMARK SENSOR CLS
PLANE EXTRACTOR PLEX
340
320
312
313
311
311
KINEMATIC ODOMETRIC UNIT KINE
310
302
301
SENSOR DATA
IMAGE DATA

FIG.4

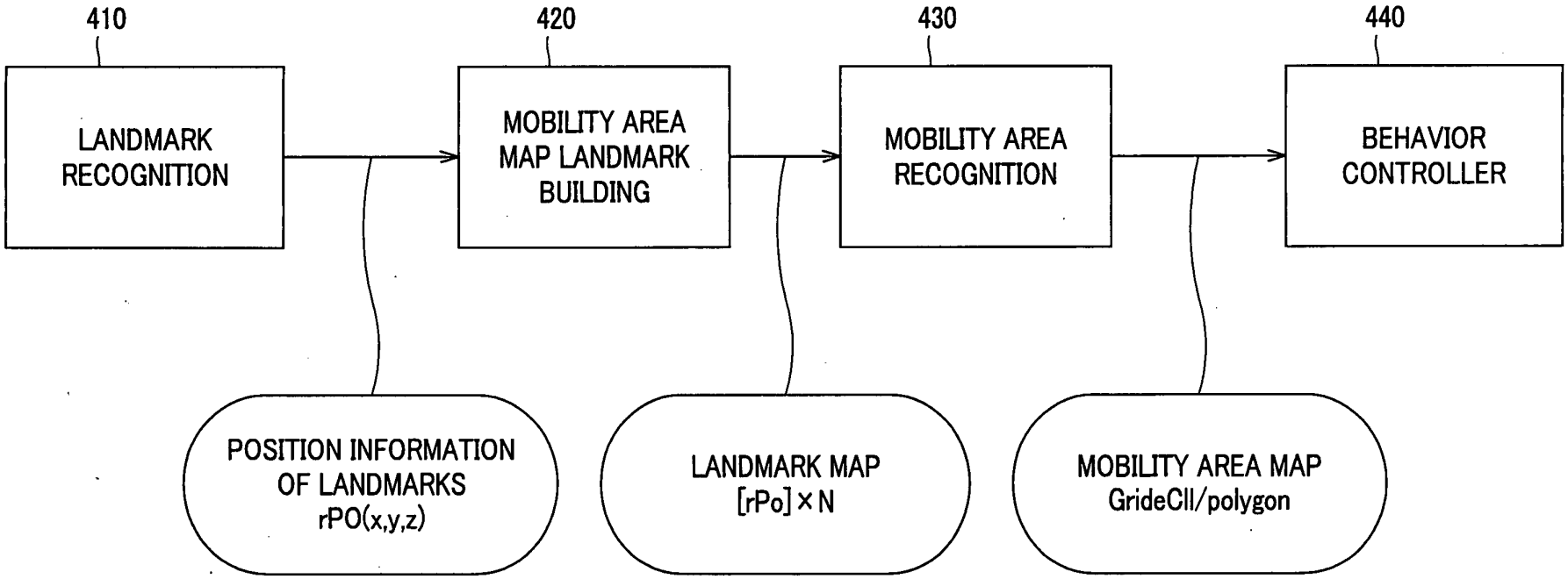

410
420
430
440
LANDMARK RECOGNITION
MOBILITY AREA MAP LANDMARK BUILDING
MOBILITY AREA RECOGNITION
BEHAVIOR CONTROLLER
POSITION INFORMATION OF LANDMARKS rPO(x,y,z)
LANDMARK MAP [rPo] × N
MOBILITY AREA MAP GrideCll/polygon

FIG.5

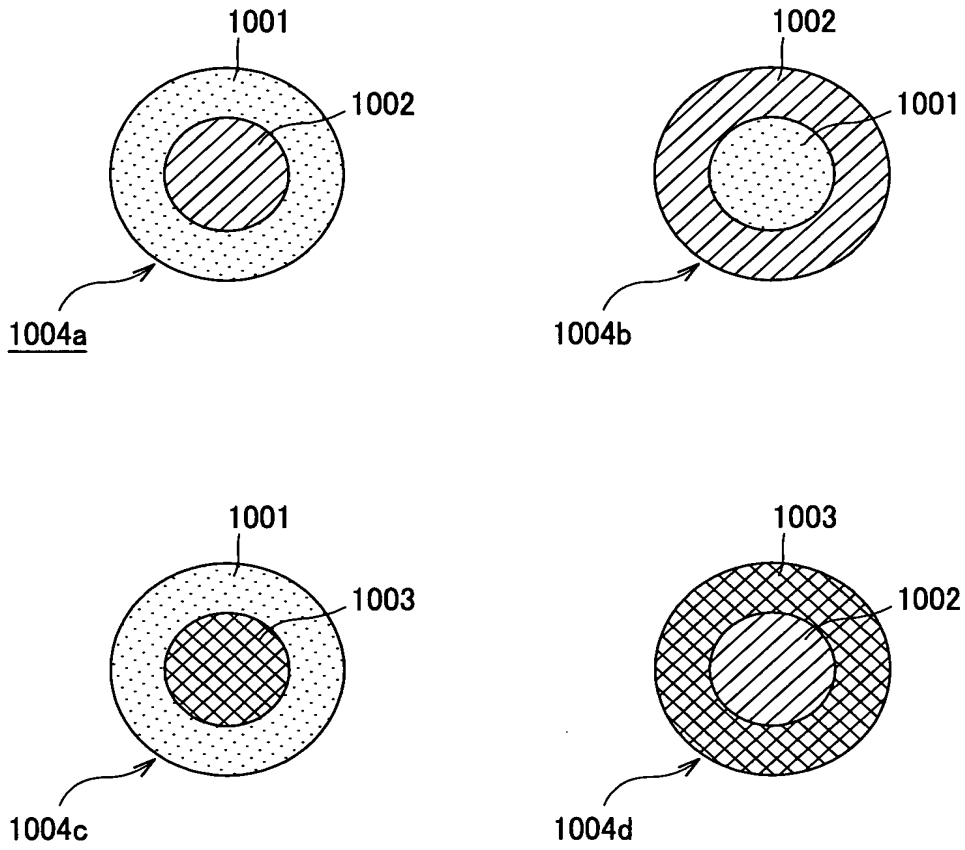
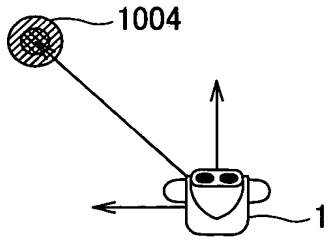
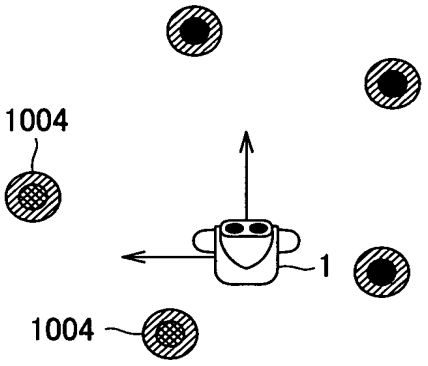

1001
1002
1004a
1002
1001
1004b
1001
1003
1004c
1003
1002
1004d

FIG.6



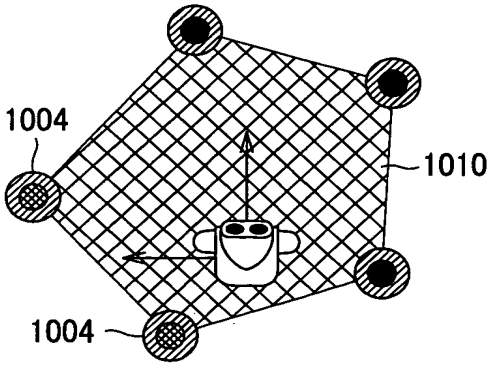
Landmark Information

FIG.7A



Landmark Map

FIG.7B



Mobility Map

FIG.7C

FIG.8A

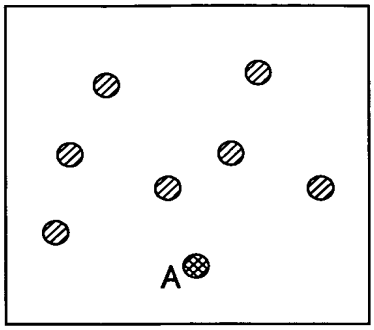


FIG.8B

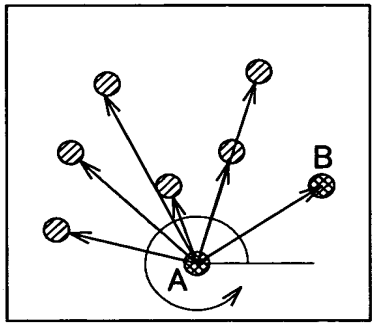


FIG.8C

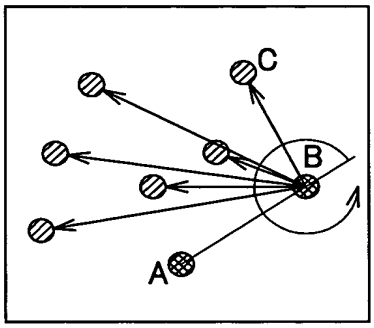
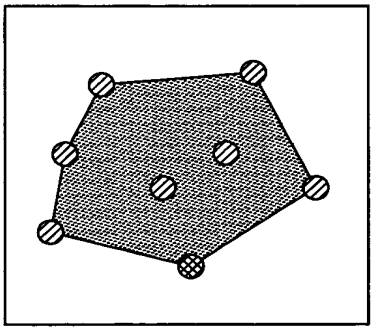


FIG.8D



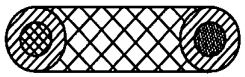


FIG.9A

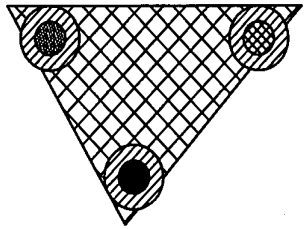


FIG.9B

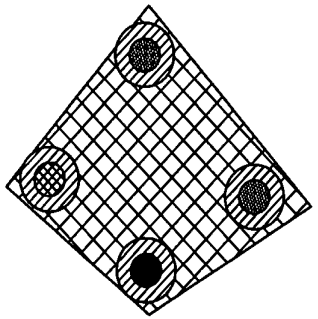


FIG.9C

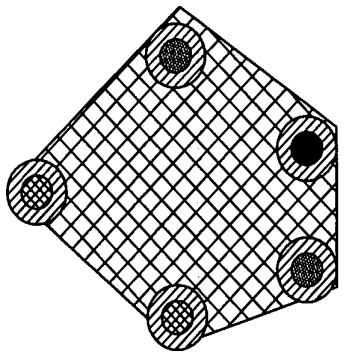


FIG.9D

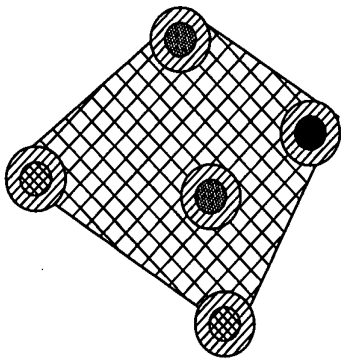


FIG.9E

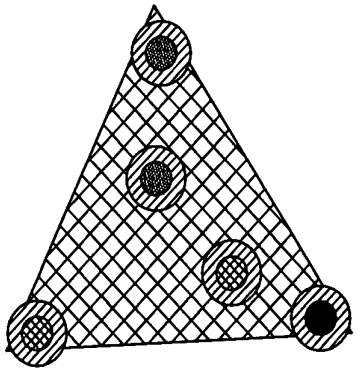


FIG.9F

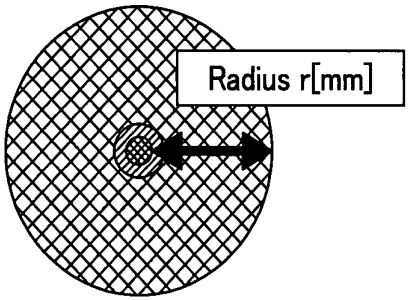


FIG.10A

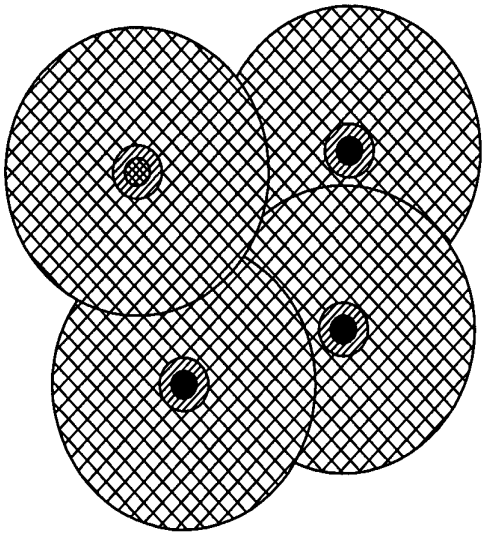


FIG.10B

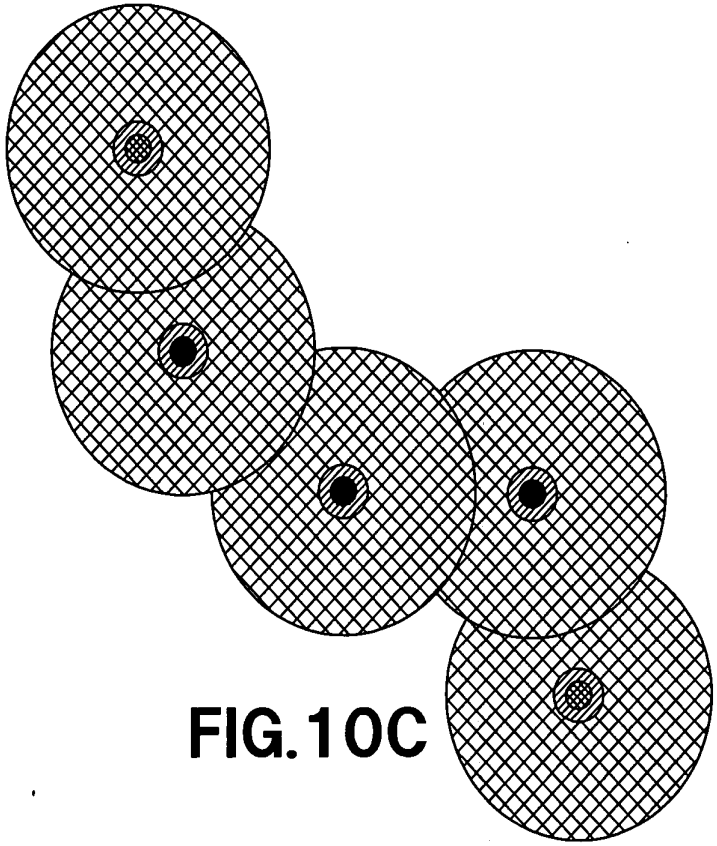


FIG.10C

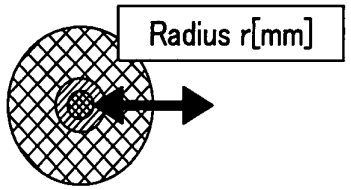


FIG.11A

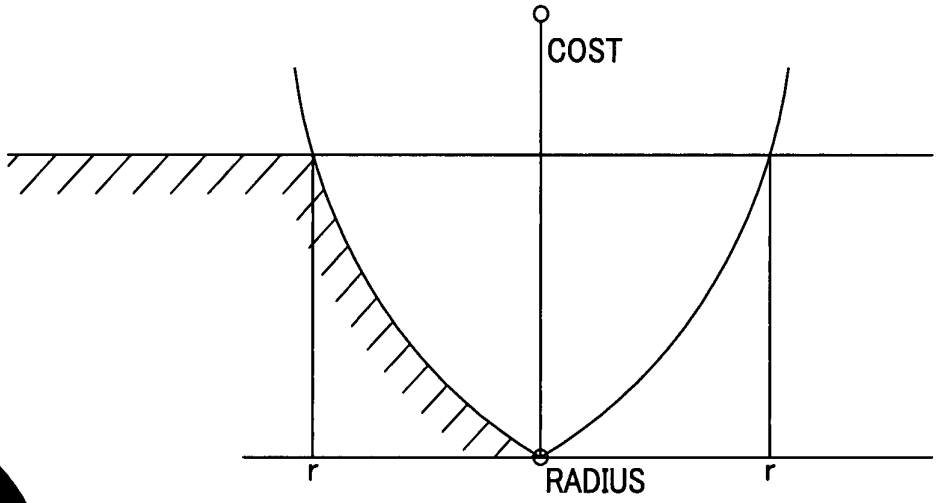


FIG.11B

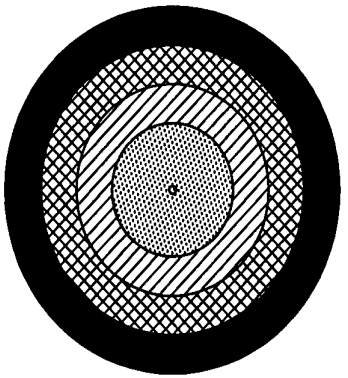
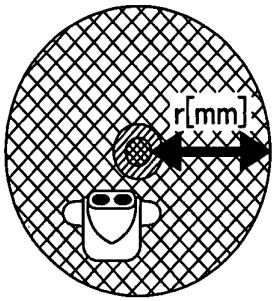


FIG.11C

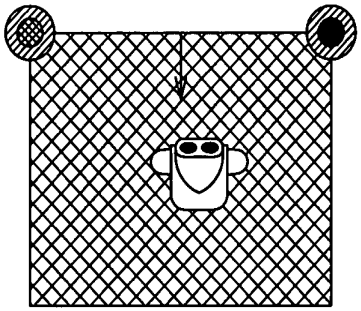
N=1



AREA METHOD

FIG.12A

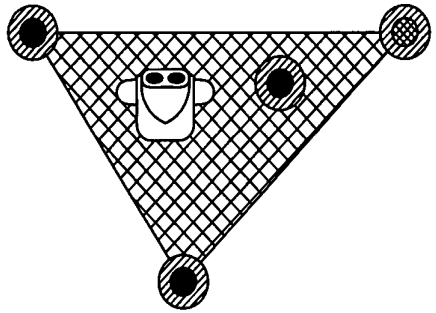
N=2



ROBOT SIDE

FIG.12B

N>2



CONVEX CLOSURE

FIG.12C

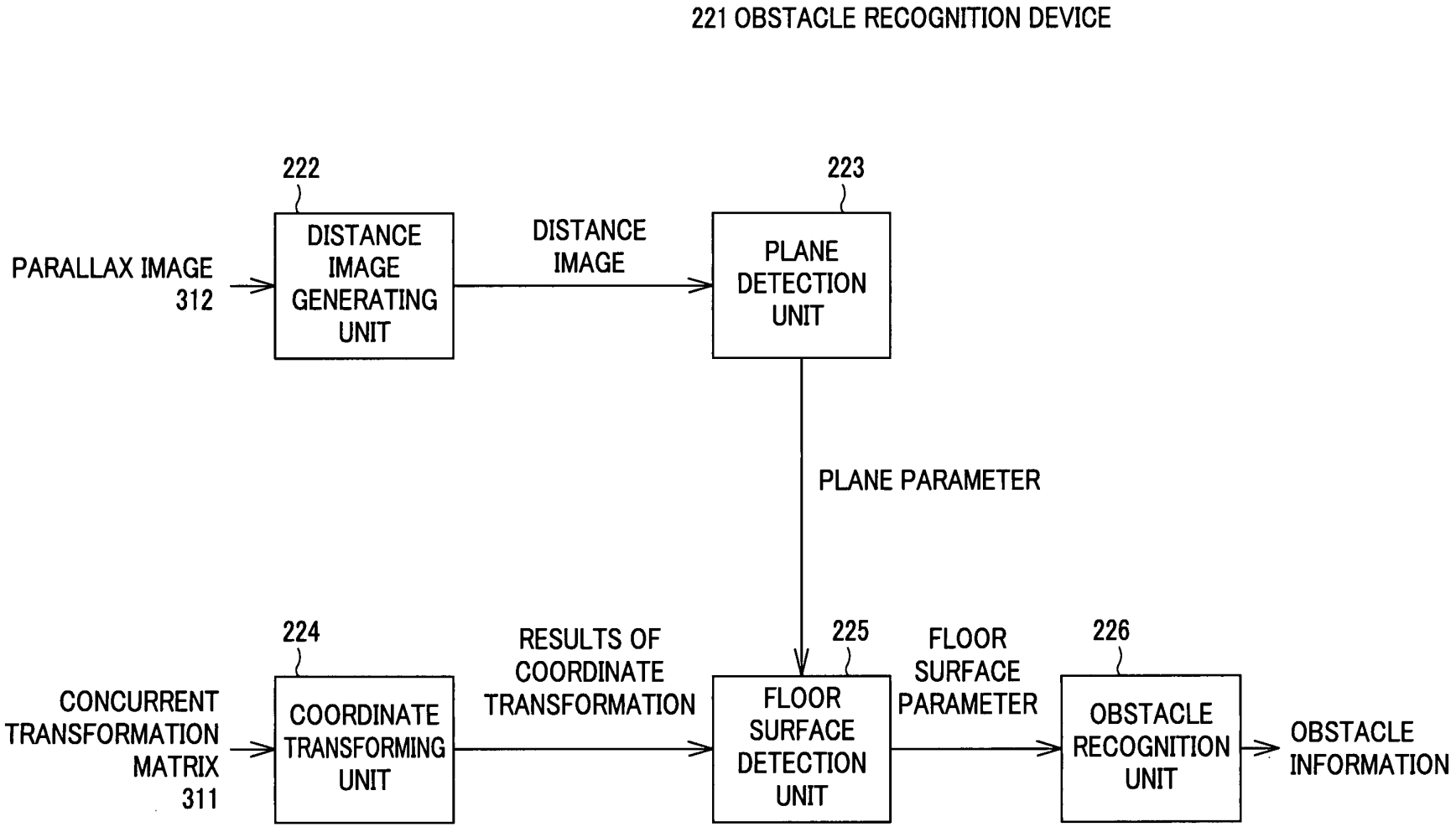
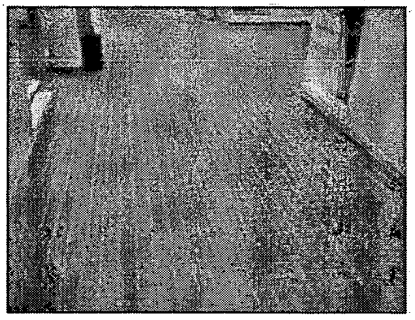
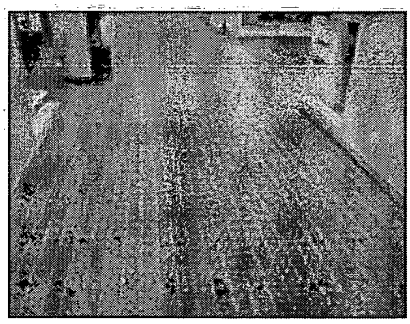

221 OBSTACLE RECOGNITION DEVICE
222
223
PARALLAX IMAGE 312
DISTANCE IMAGE GENERATING UNIT
DISTANCE IMAGE
PLANE DETECTION UNIT
PLANE PARAMETER
224
225
226
CONCURRENT TRANSFORMATION MATRIX 311
COORDINATE TRANSFORMING UNIT
RESULTS OF COORDINATE TRANSFORMATION
FLOOR SURFACE DETECTION UNIT
FLOOR SURFACE PARAMETER
OBSTACLE RECOGNITION UNIT
OBSTACLE INFORMATION

FIG.13



201L LEFT-EYE IMAGE



201R RIGHT-EYE IMAGE

312 PARALLAX IMAGE

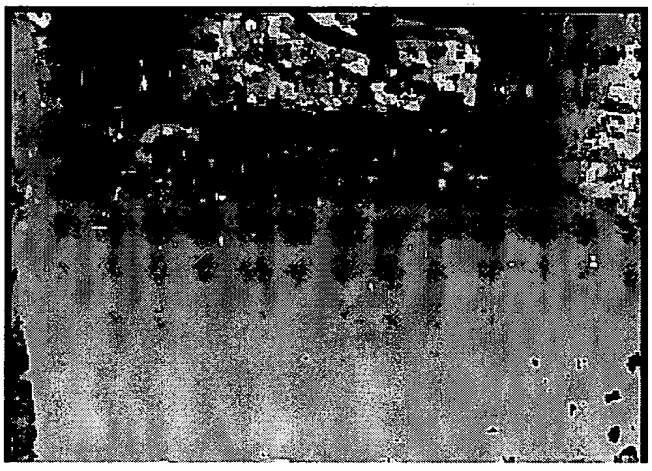


FIG.14

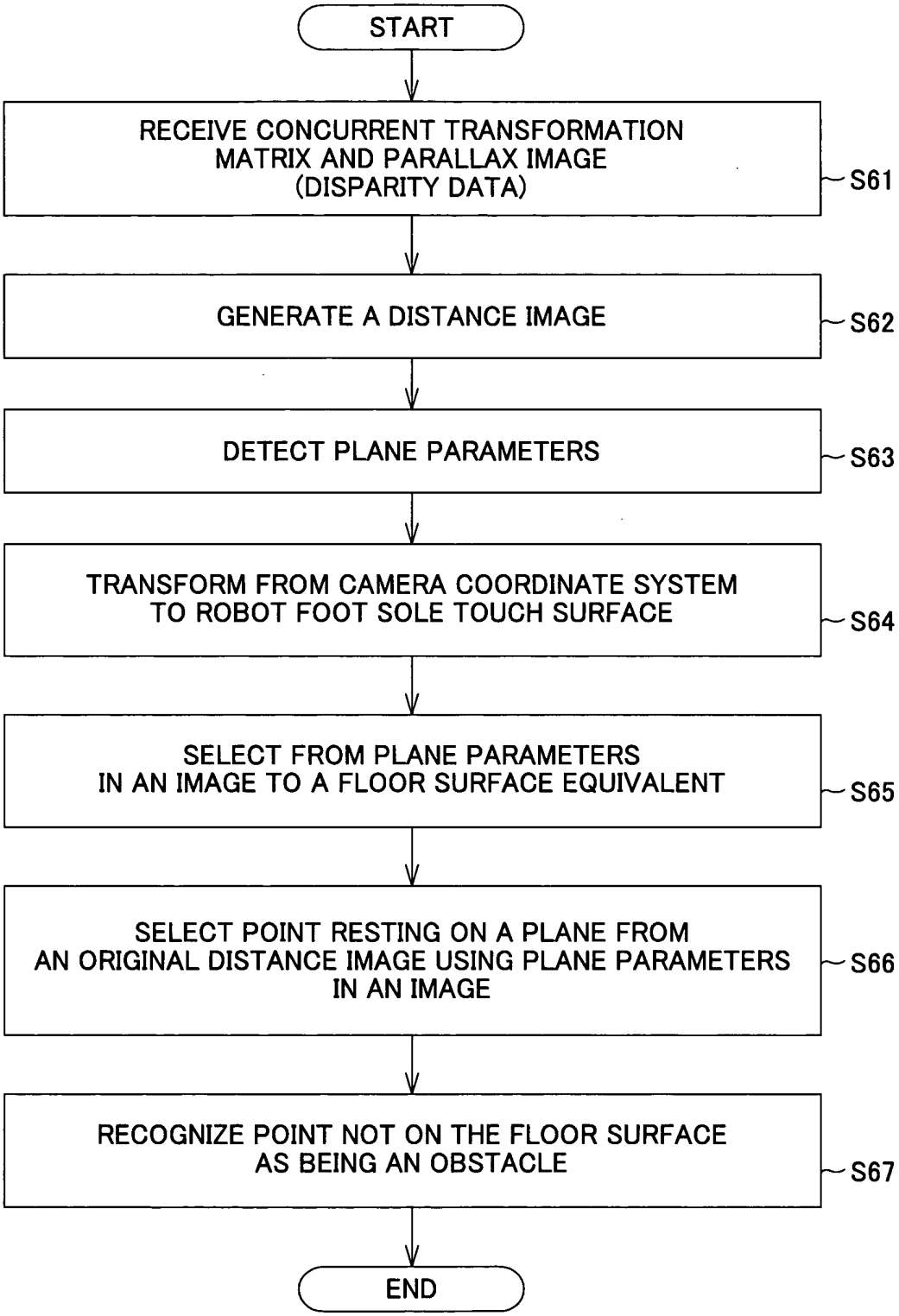

START
RECEIVE CONCURRENT TRANSFORMATION MATRIX AND PARALLAX IMAGE (DISPARITY DATA)
S61
GENERATE A DISTANCE IMAGE
S62
DETECT PLANE PARAMETERS
S63
TRANSFORM FROM CAMERA COORDINATE SYSTEM TO ROBOT FOOT SOLE TOUCH SURFACE
S64
SELECT FROM PLANE PARAMETERS IN AN IMAGE TO A FLOOR SURFACE EQUIVALENT
S65
SELECT POINT RESTING ON A PLANE FROM AN ORIGINAL DISTANCE IMAGE USING PLANE PARAMETERS IN AN IMAGE
S66
RECOGNIZE POINT NOT ON THE FLOOR SURFACE AS BEING AN OBSTACLE
S67
END

FIG.15

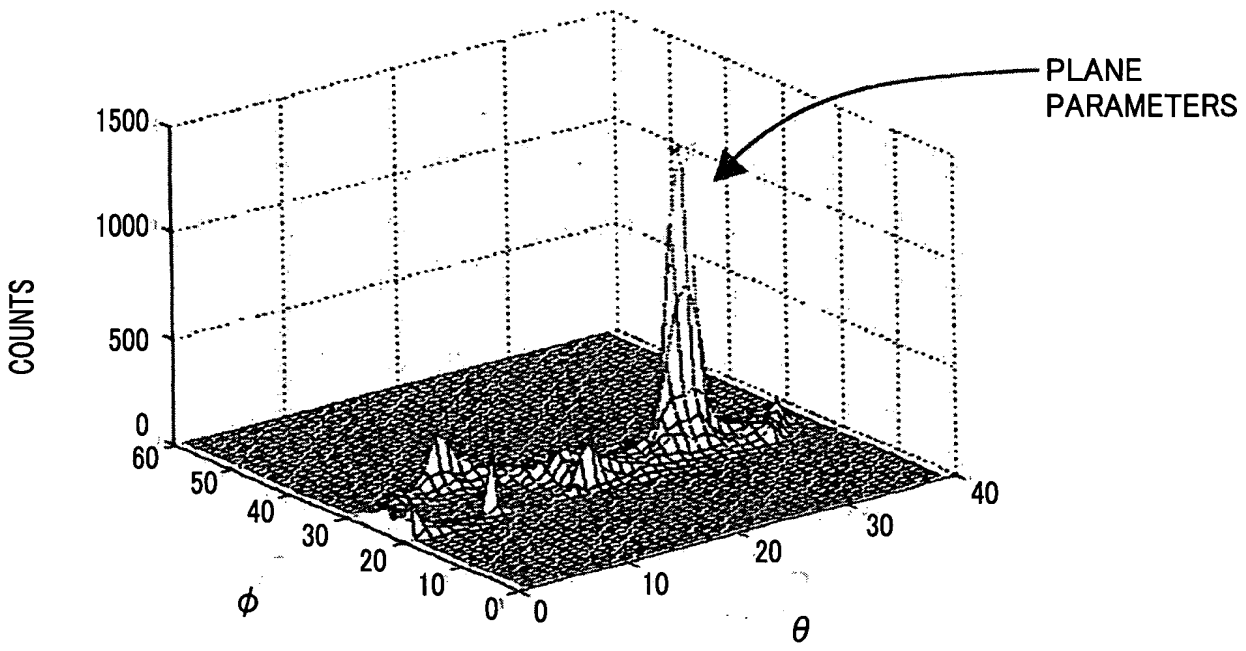

PLANE
PARAMETERS
COUNTS
1500
1000
500
0
60
50
40
30
20
10
0
ϕ
0
10
20
30
40
θ

FIG.16

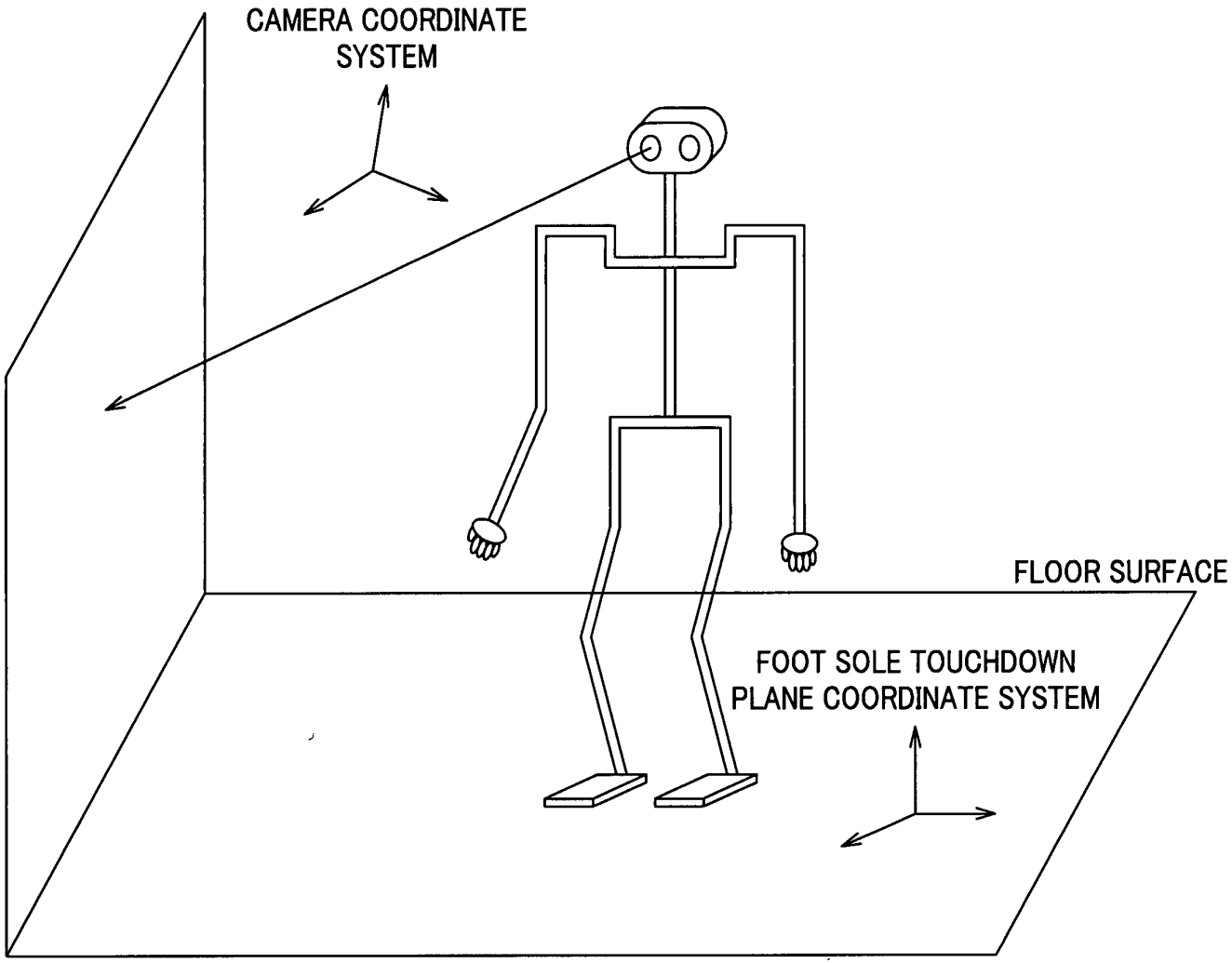
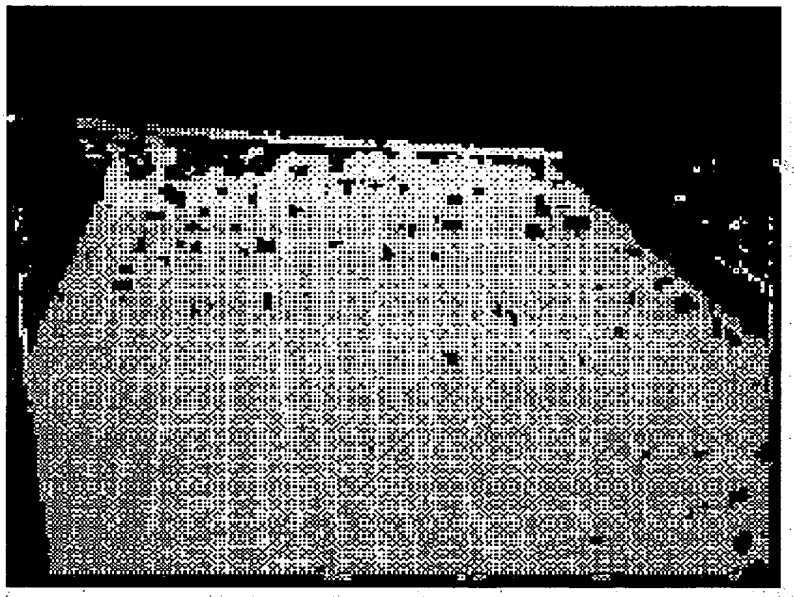
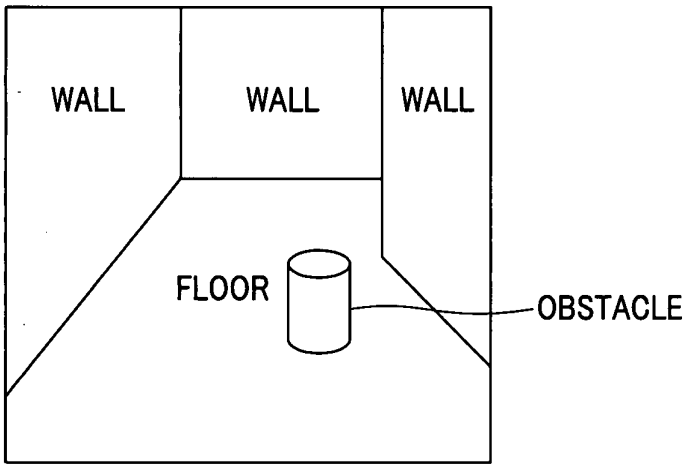

CAMERA COORDINATE
SYSTEM
FLOOR SURFACE
FOOT SOLE TOUCHDOWN
PLANE COORDINATE SYSTEM

FIG.17



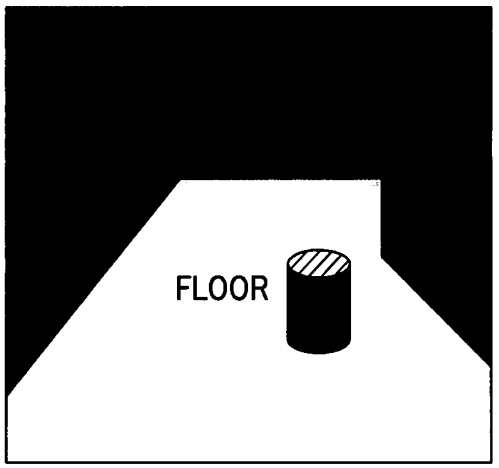
Dth=10mm

FIG.18



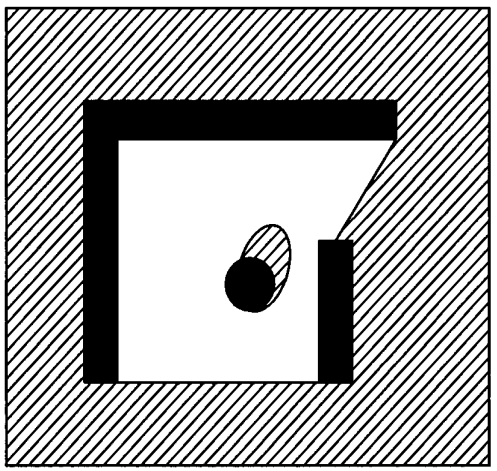
ROBOT VIEW

FIG.19A



FLOOR SURFACE EXTRACTION

FIG.19B



COORDINATE TRANSFORMATION

EXPRESSION ON FLOOR SURFACE

FIG.19C

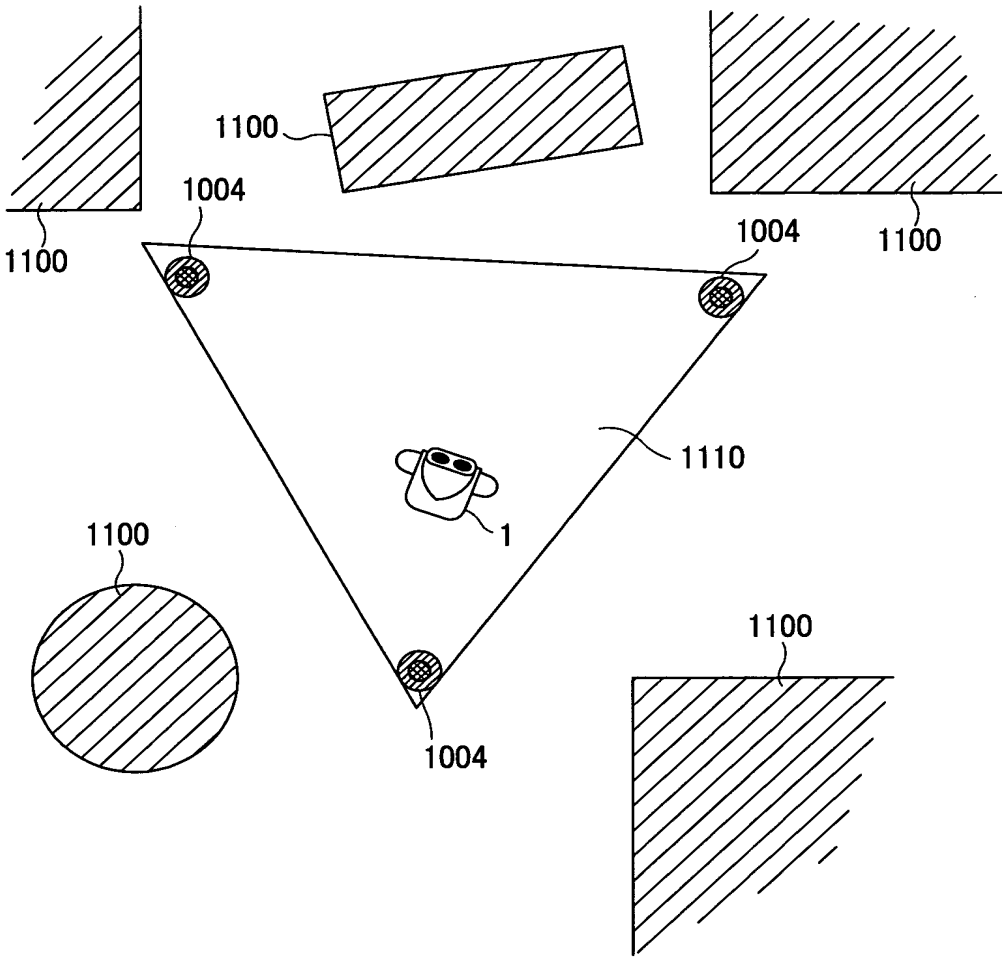


FIG.20

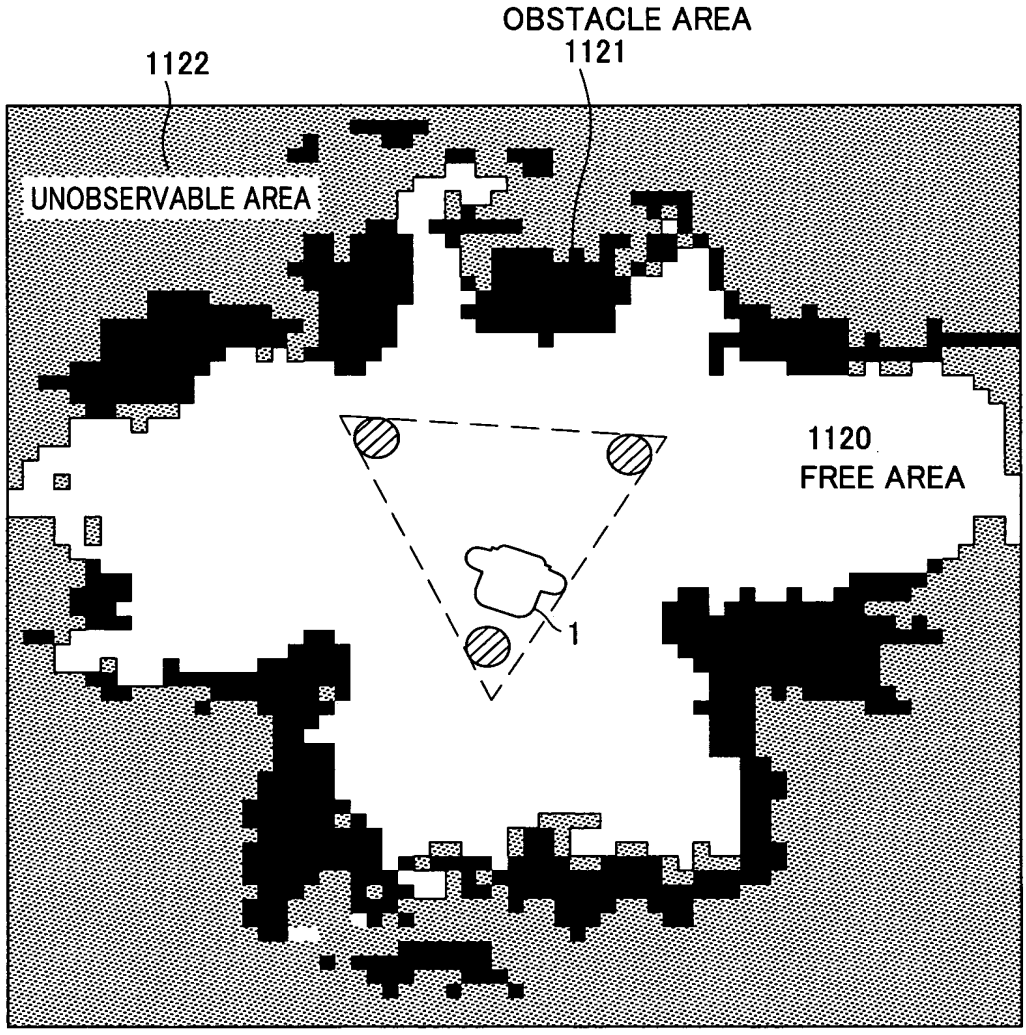


FIG.21

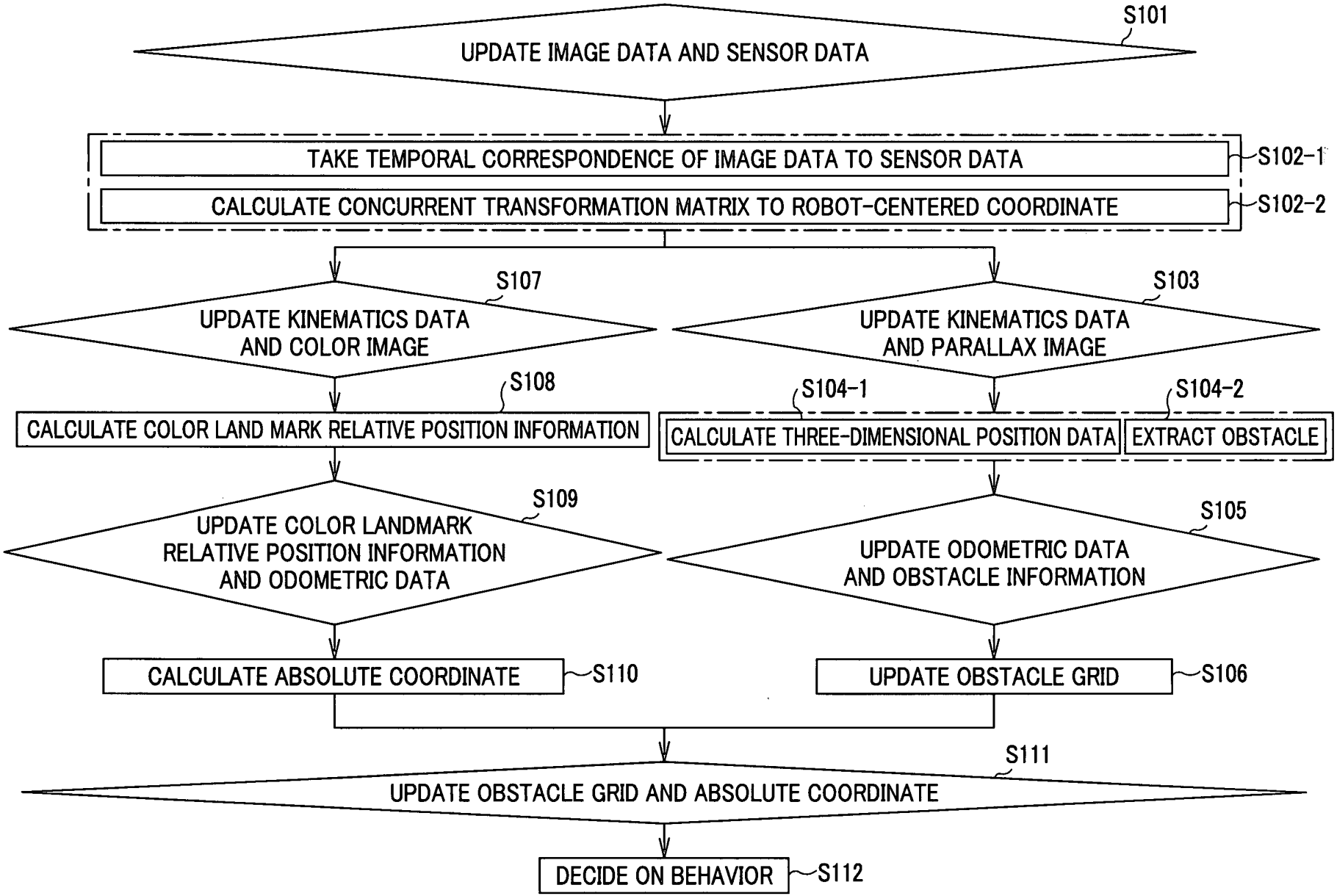

S101
UPDATE IMAGE DATA AND SENSOR DATA
TAKE TEMPORAL CORRESPONDENCE OF IMAGE DATA TO SENSOR DATA
S102-1
CALCULATE CONCURRENT TRANSFORMATION MATRIX TO ROBOT-CENTERED COORDINATE
S102-2
S107
UPDATE KINEMATICS DATA AND COLOR IMAGE
S103
UPDATE KINEMATICS DATA AND PARALLAX IMAGE
S108
CALCULATE COLOR LAND MARK RELATIVE POSITION INFORMATION
S104-1
CALCULATE THREE-DIMENSIONAL POSITION DATA
S104-2
EXTRACT OBSTACLE
S109
UPDATE COLOR LANDMARK RELATIVE POSITION INFORMATION AND ODOMETRIC DATA
S105
UPDATE ODOMETRIC DATA AND OBSTACLE INFORMATION
CALCULATE ABSOLUTE COORDINATE
S110
UPDATE OBSTACLE GRID
S106
S111
UPDATE OBSTACLE GRID AND ABSOLUTE COORDINATE
DECIDE ON BEHAVIOR
S112

FIG.22

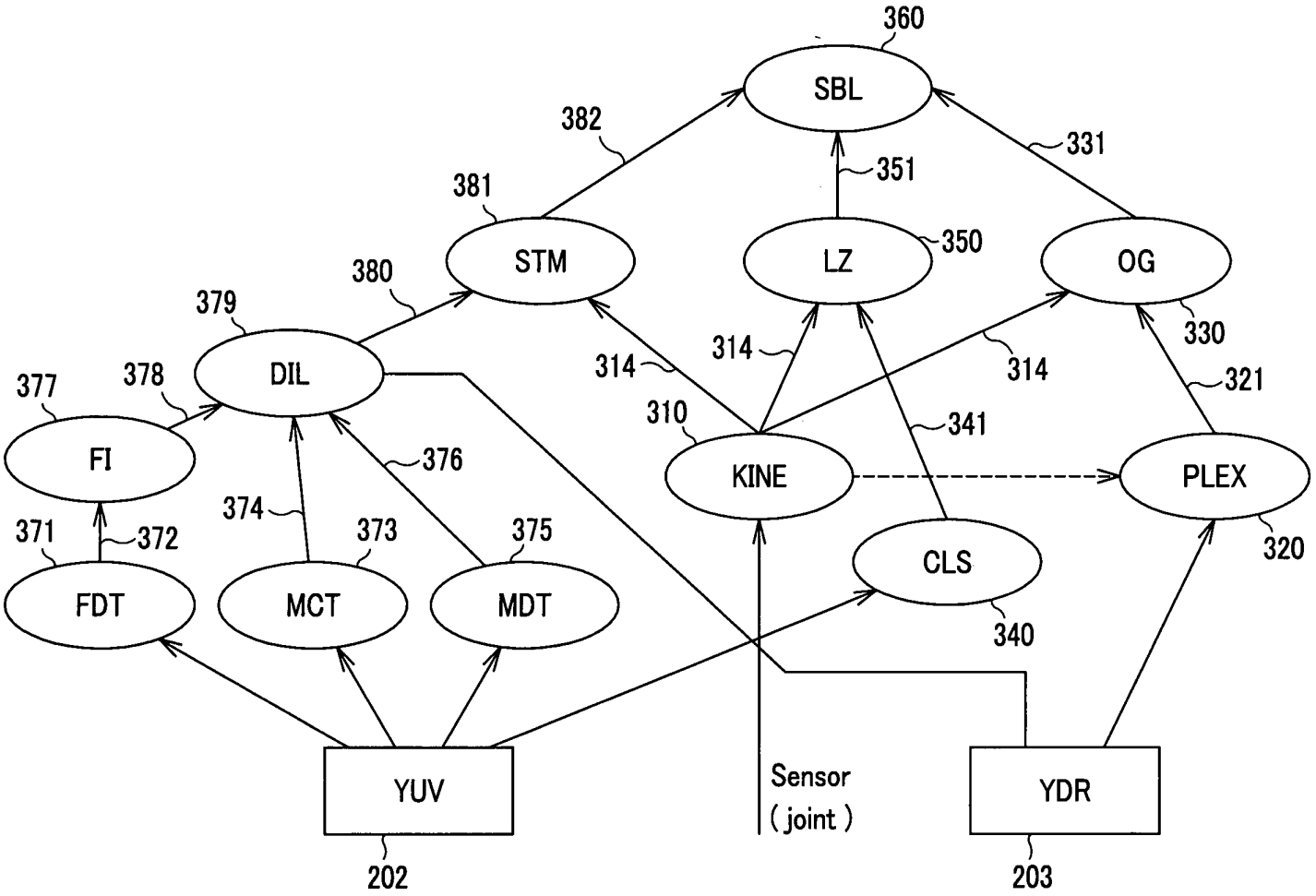

360
SBL
382
331
351
381
STM
LZ
350
OG
380
379
330
314
314
314
377
378
DIL
321
310
341
FI
376
KINE
PLEX
374
371
372
373
375
320
CLS
FDT
MCT
MDT
340
YUV
Sensor
(joint)
YDR
202
203

FIG.23

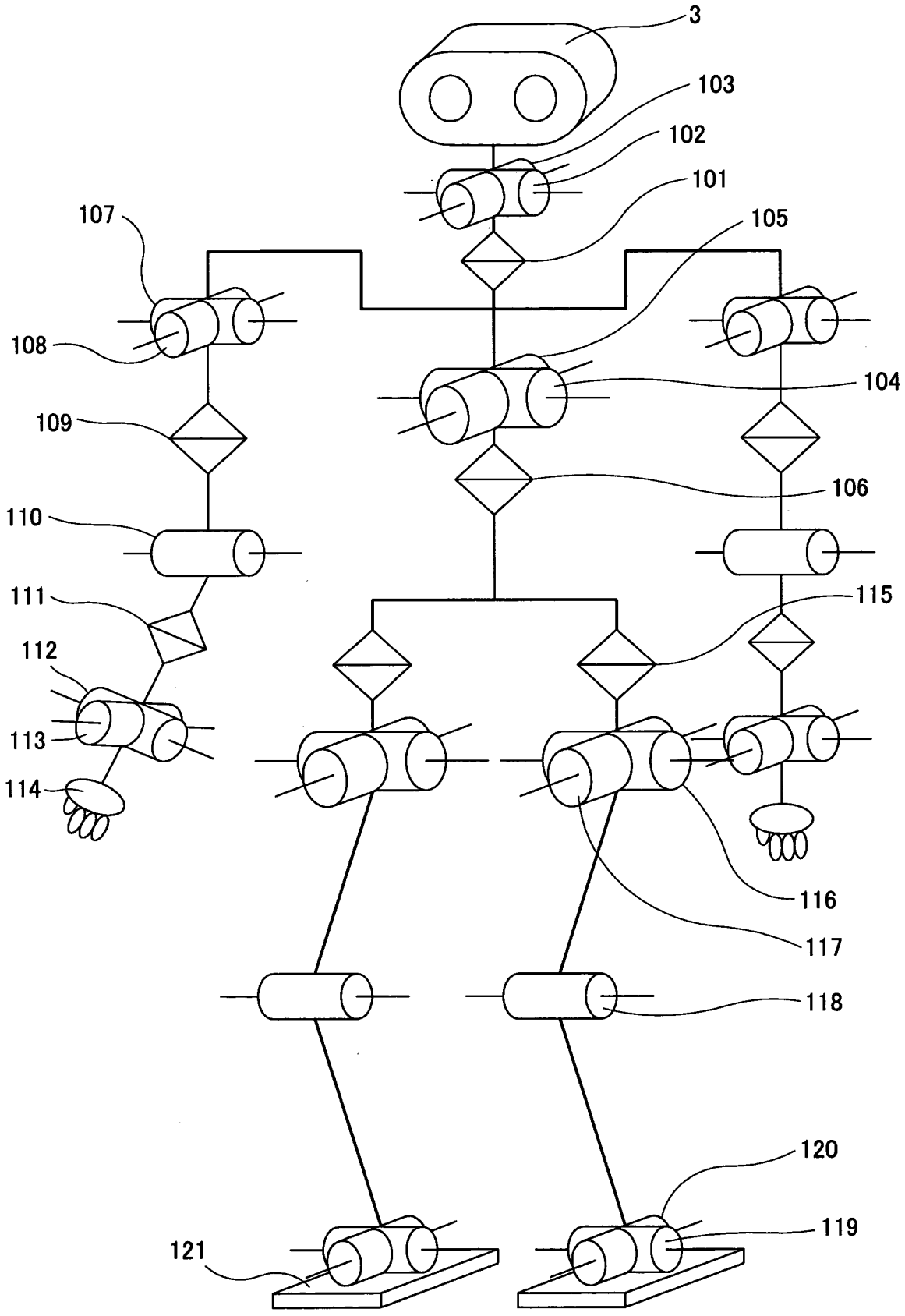

3
103
102
101
107
105
108
104
109
106
110
115
111
112
113
116
114
117
118
120
121
119

FIG.24

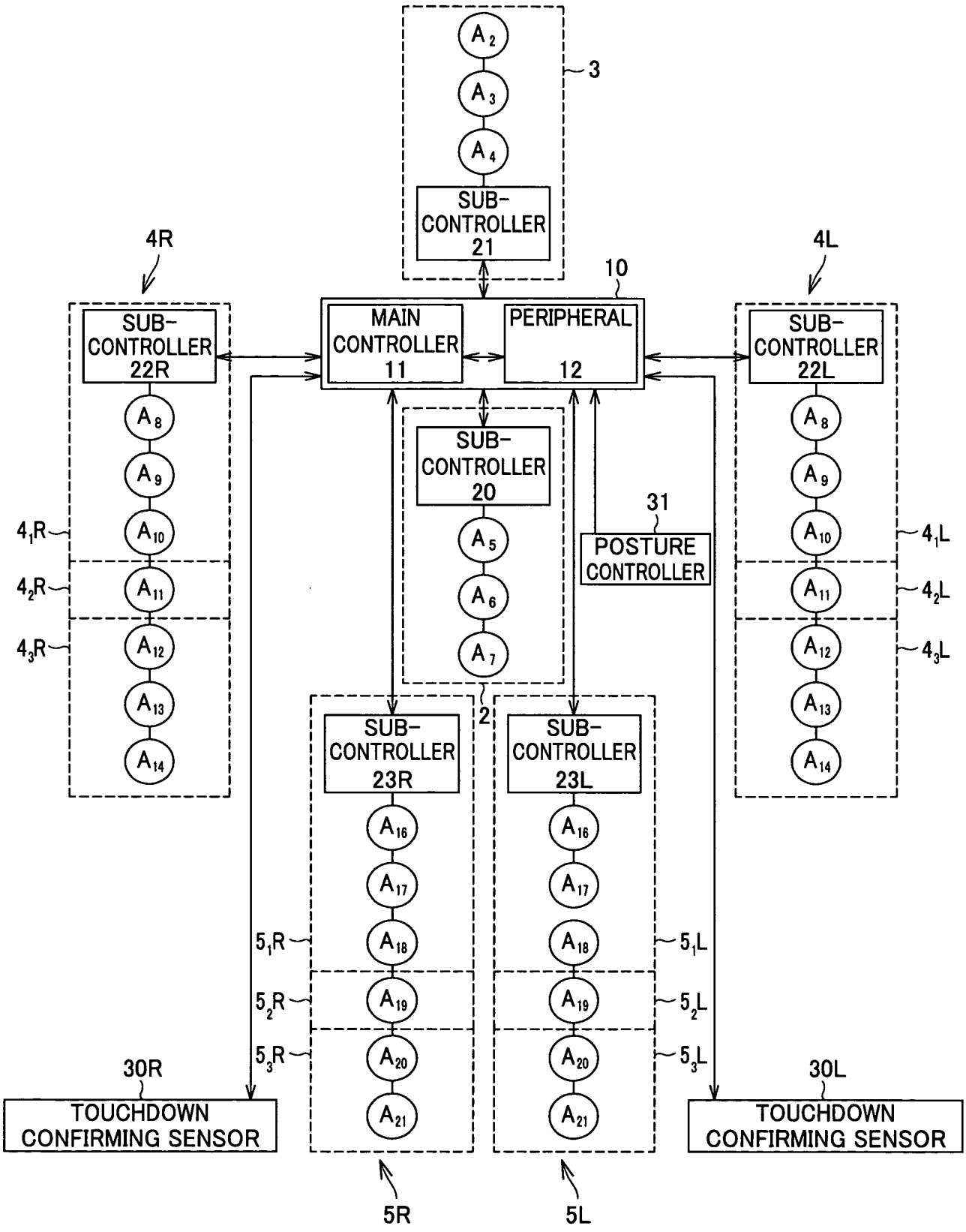

A2
A3
A4
3
SUB-CONTROLLER 21
10
4R
4L
SUB-CONTROLLER 22R
MAIN CONTROLLER 11
PERIPHERAL 12
SUB-CONTROLLER 22L
A8
A9
A10
A11
A12
A13
A14
41R
42R
43R
41L
42L
43L
SUB-CONTROLLER 20
A5
A6
A7
31
POSTURE CONTROLLER
2
SUB-CONTROLLER 23R
SUB-CONTROLLER 23L
A16
A17
A18
A19
A20
A21
51R
52R
53R
51L
52L
53L
30R
30L
TOUCHDOWN CONFIRMING SENSOR
TOUCHDOWN CONFIRMING SENSOR
5R
5L

FIG.25

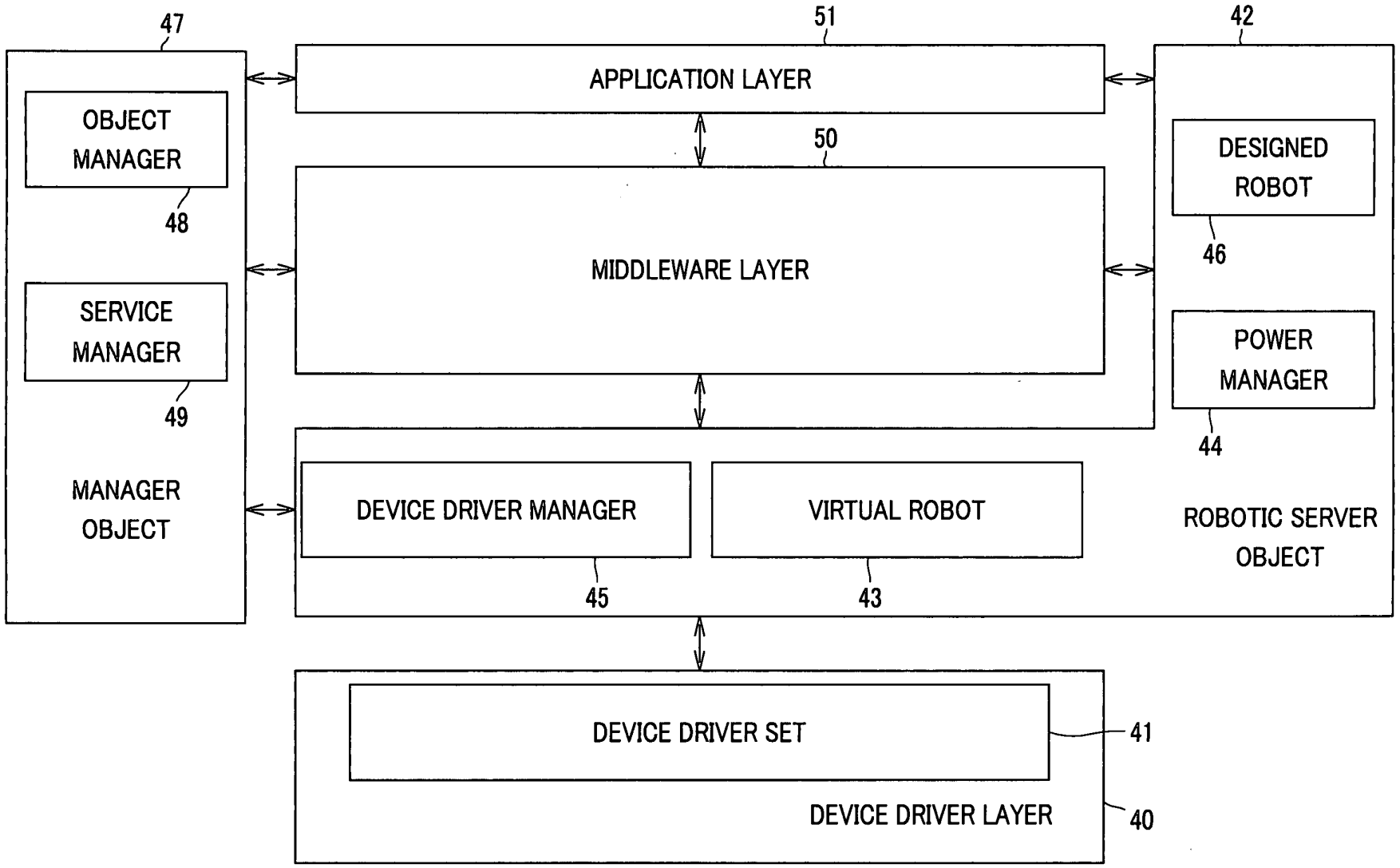

47
51
42
APPLICATION LAYER
OBJECT MANAGER
48
50
DESIGNED ROBOT
46
MIDDLEWARE LAYER
SERVICE MANAGER
49
POWER MANAGER
44
MANAGER OBJECT
DEVICE DRIVER MANAGER
VIRTUAL ROBOT
ROBOTIC SERVER OBJECT
45
43
DEVICE DRIVER SET
41
DEVICE DRIVER LAYER
40

FIG.26

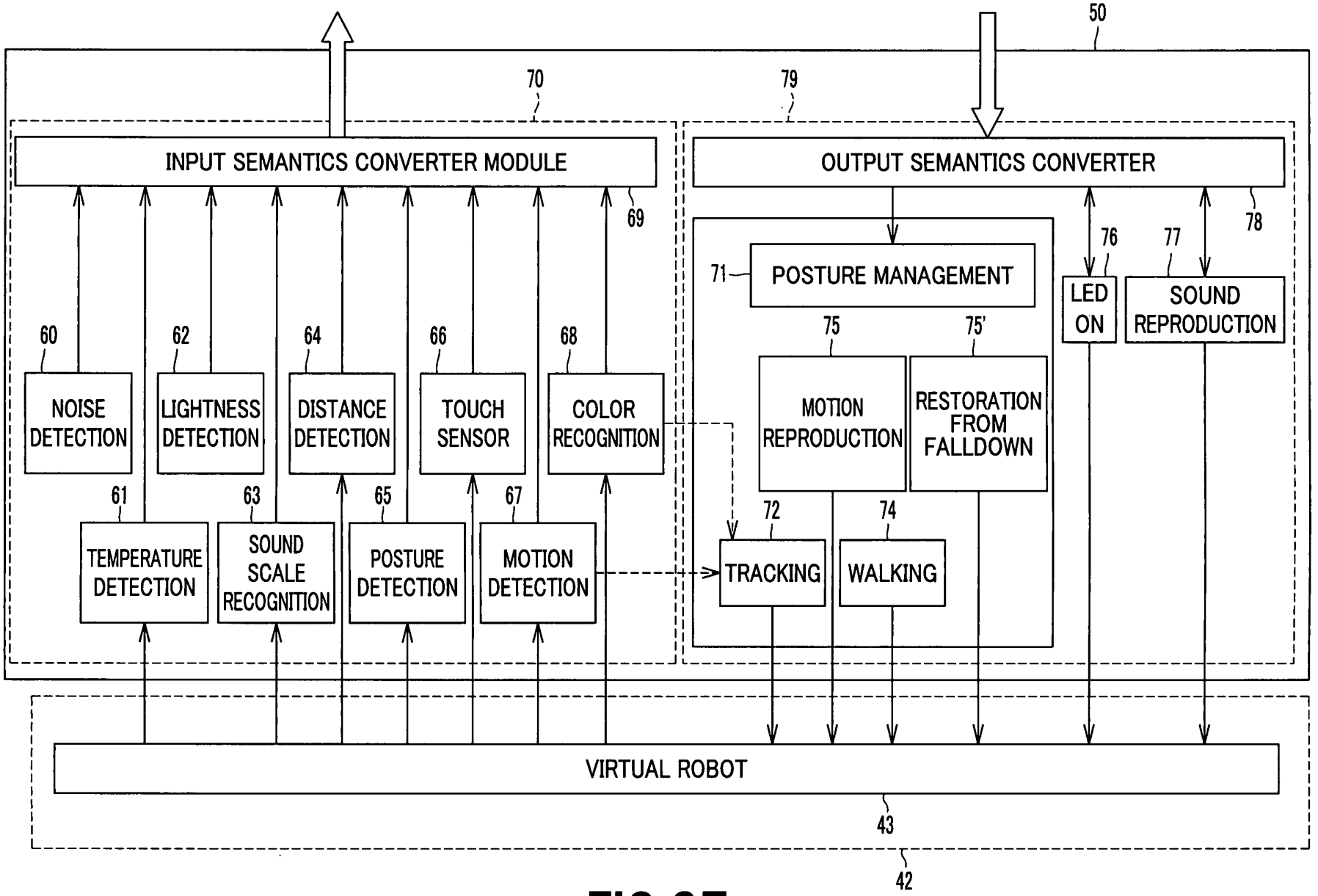

50
70
79
INPUT SEMANTICS CONVERTER MODULE
OUTPUT SEMANTICS CONVERTER
69
78
76
77
71
POSTURE MANAGEMENT
LED ON
SOUND REPRODUCTION
75
75'
60
62
64
66
68
NOISE DETECTION
LIGHTNESS DETECTION
DISTANCE DETECTION
TOUCH SENSOR
COLOR RECOGNITION
MOTION REPRODUCTION
RESTORATION FROM FALLDOWN
61
63
65
67
72
74
TEMPERATURE DETECTION
SOUND SCALE RECOGNITION
POSTURE DETECTION
MOTION DETECTION
TRACKING
WALKING
VIRTUAL ROBOT
43
42

FIG.27

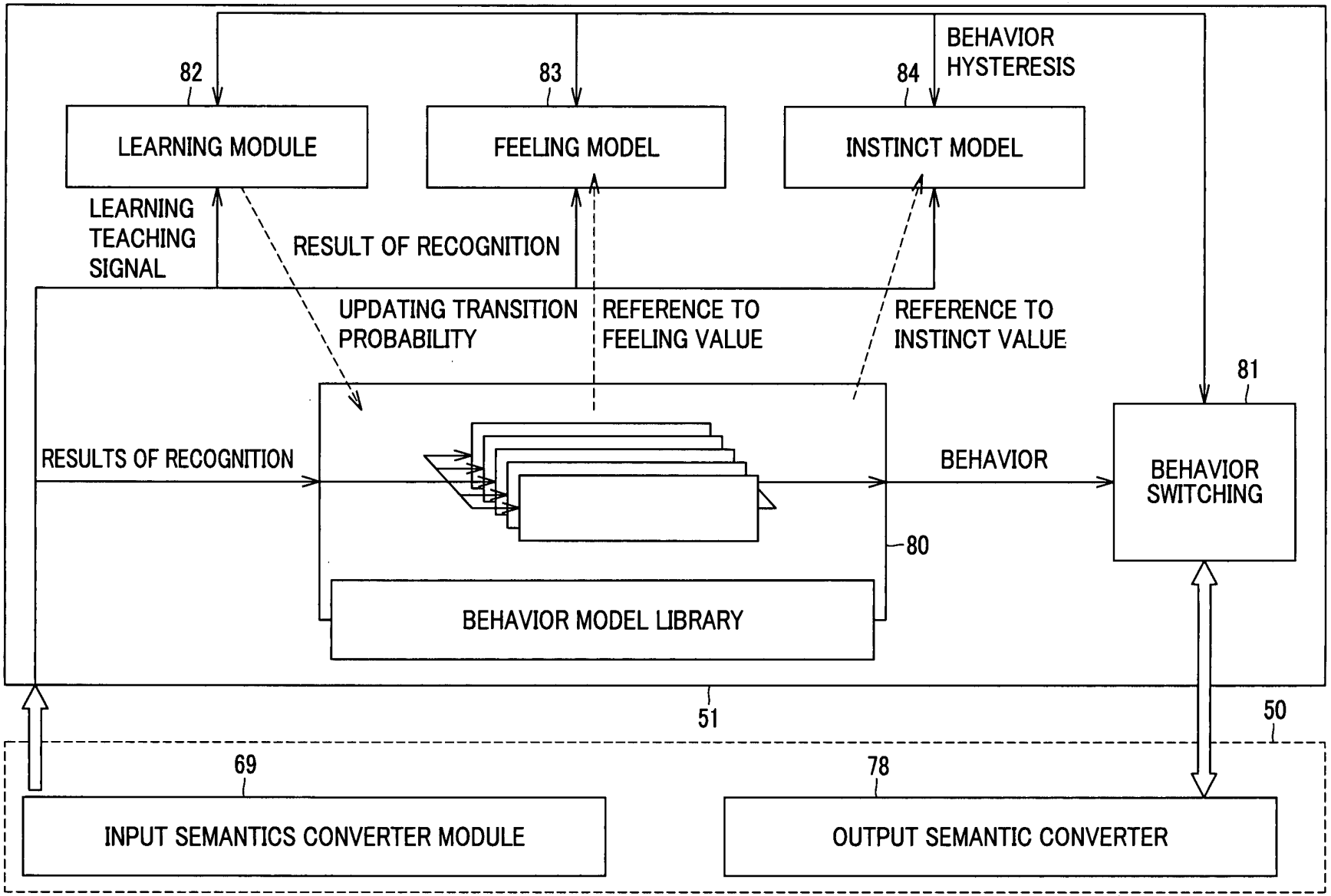

82
83
84
BEHAVIOR HYSTERESIS
LEARNING MODULE
FEELING MODEL
INSTINCT MODEL
LEARNING TEACHING SIGNAL
RESULT OF RECOGNITION
UPDATING TRANSITION PROBABILITY
REFERENCE TO FEELING VALUE
REFERENCE TO INSTINCT VALUE
81
RESULTS OF RECOGNITION
BEHAVIOR
BEHAVIOR SWITCHING
80
BEHAVIOR MODEL LIBRARY
51
50
69
78
INPUT SEMANTICS CONVERTER MODULE
OUTPUT SEMANTIC CONVERTER

FIG.28

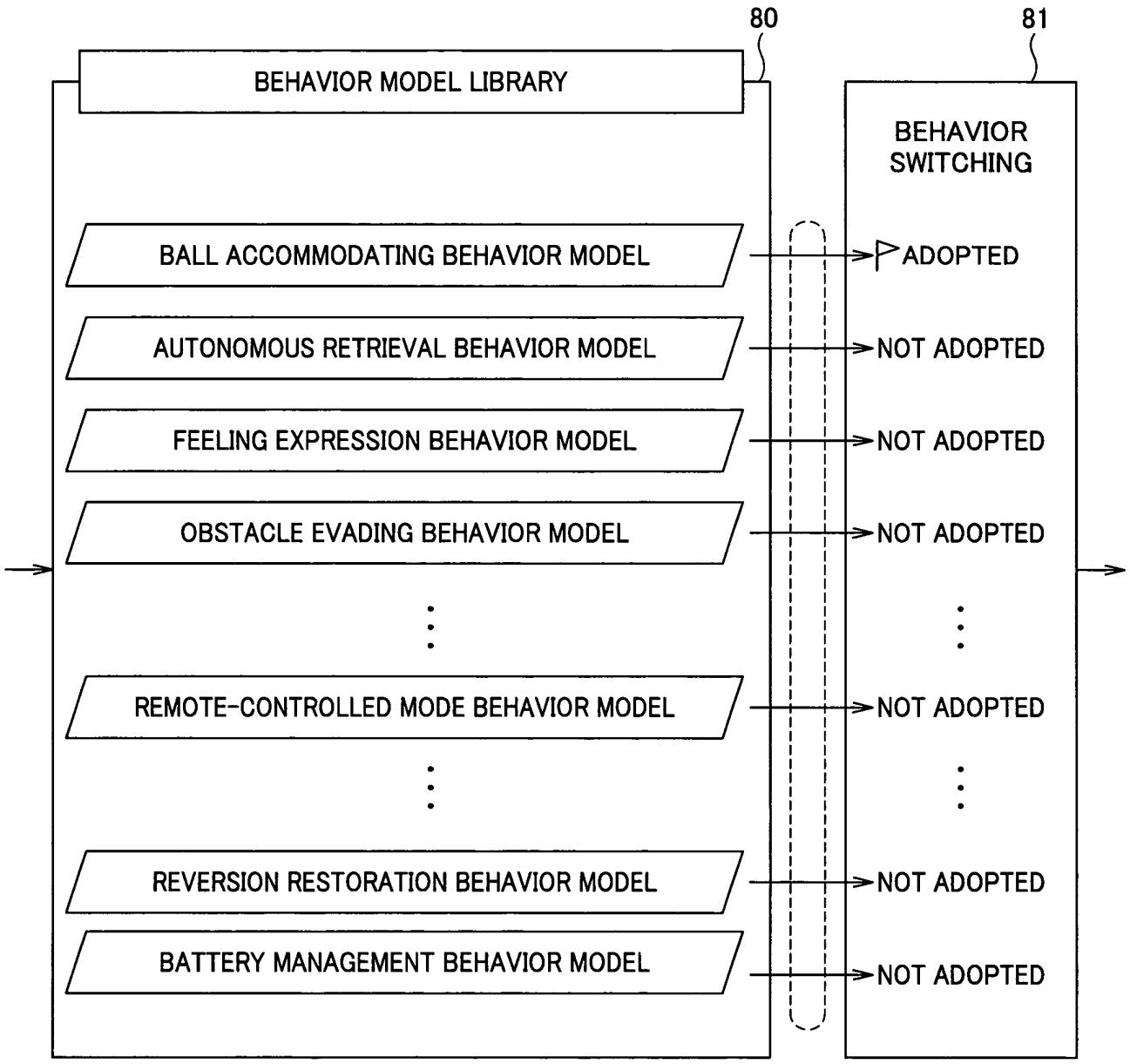

80
81
BEHAVIOR MODEL LIBRARY
BEHAVIOR SWITCHING
BALL ACCOMMODATING BEHAVIOR MODEL
ADOPTED
AUTONOMOUS RETRIEVAL BEHAVIOR MODEL
NOT ADOPTED
FEELING EXPRESSION BEHAVIOR MODEL
NOT ADOPTED
OBSTACLE EVADING BEHAVIOR MODEL
NOT ADOPTED
REMOTE-CONTROLLED MODE BEHAVIOR MODEL
NOT ADOPTED
REVERSION RESTORATION BEHAVIOR MODEL
NOT ADOPTED
BATTERY MANAGEMENT BEHAVIOR MODEL
NOT ADOPTED

FIG.29

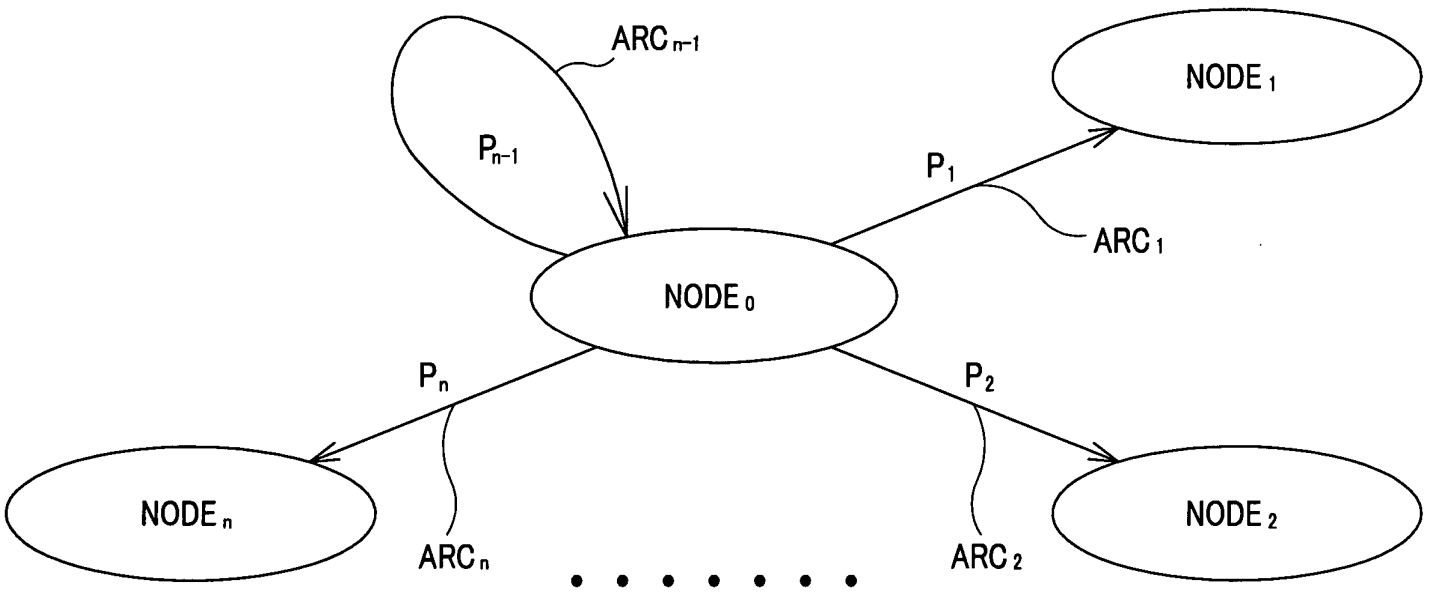


FIG.30

	INPUT EVENT NAME	DATA NAME	DATA RANGE	PROBABILITY OF TRANSITION TO OTHER NODES					
node 100				A	B	C	D		n
NODE OF TRANSITION DESTINATION				node 120	node 120	node 1000			node 600
OUTPUT BEHAVIOR				ACTION 1	ACTION 2	MOVE BACK			ACTION 4
1	BALL	SIZE	0.1000	30%					
2	PAT				40%				
3	HIT				20%				
4	MOTION					50%			
5	OBSTACLE	DISTANCE	0.100			100%			
6		JOY	50.100						
7		SURPRISE	50.100						
8		SADNESS	50.100						

90

FIG.31